Structural characterization of wet-etched quaternary InAlGaN barrier HEMT structure

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The quaternary nitride-based high electron mobility transistor (HEMT) has been recently a focus of interest because of the possibility to grow lattice-matched barrier to GaN and tune the barrier bandgap at the same time [1]. The reduction of strain-related defects, the high polarization at the interface and high carrier mobility of the 2-dimensional electron gas (2DEG) make InAlGaN a viable way to improve HEMT quality and performance, reaching values of f_T of 220 GHz [2]. In particular, very few reports focus on strain relaxation mechanism and composition dependence [1].
In this work we focused on the characterization of wet-etched (AZ400K photoresist developer, 10 min., 80 °C) $In_xAl_yGa_{1-x-y}N$ with varying x/y composition and thickness of the order of the barrier of a standard HEMT structure (between 10 and 30 nm). Based on Rutherford Backscattering Spectrometry (RBS) and X-ray Diffraction Reflection (XRD) results, we obtained information about strain and composition. In particular reciprocal space maps (RSM) of the samples could give information about crystal relaxation of the layers (Fig. 1). The samples showed fully strained growth of the barrier on GaN.
With the use of Atomic Force Microscopy (AFM) imaging, we identified preferential etching paths (Fig. 2). Depending on the composition and strain relaxation, the etching could occur preferentially through dislocations or through the weak bonding in the quaternary. For this reason, we measured a depth of preferential etching for each sample (see Table 1). Thus, we observed that the variation in the quaternary composition leads to substantial difference in etch rate and morphology of etched material.

References

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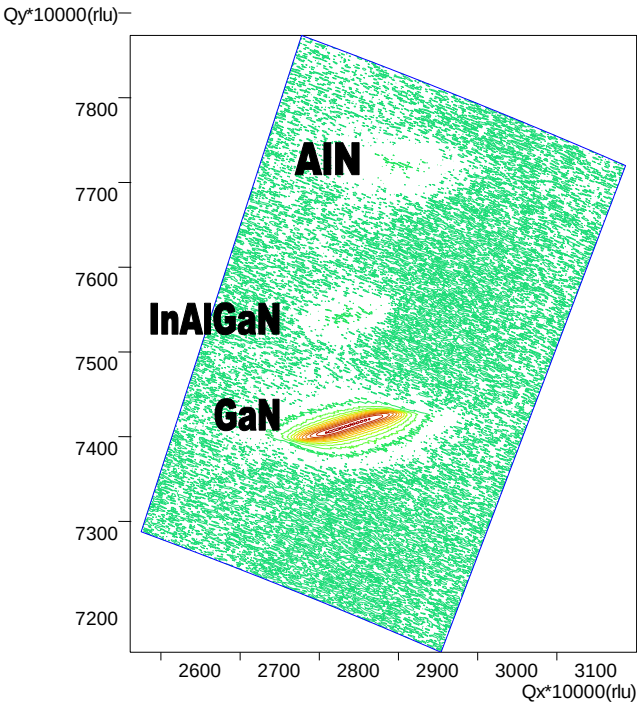

Fig.1 Reciprocal space map round [105] Bragg spots.

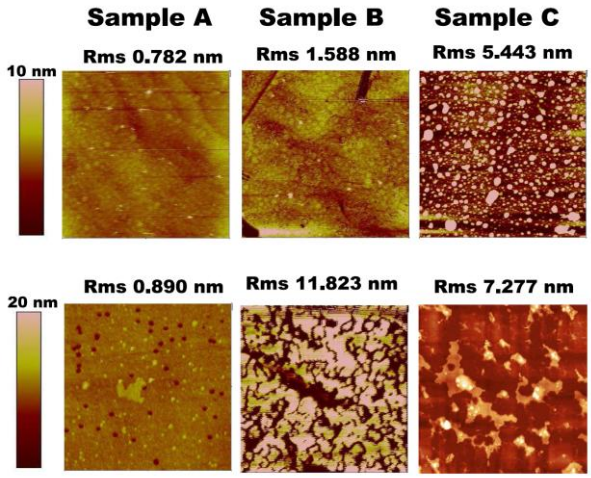

Fig.2: From left to right 5 µm × 5 µm AFM images of the samples A, B and C investigated with calculated rms values. Top images are the as-grown samples, bottom images are 10' etched samples.

Sample		RBS				XRD				AFM	
		InAlGaN				InAlGaN					
		In %	Al %	Ga%	thickness (nm)	In %	Al %	Ga%	thickness (nm)	rms (nm)	depth (nm)
A	as-grown	4.8	61.2	34	14	6.2	61.2	32.6	14.5 ± 0.5	0.782	
	10' etched					6.2	61.2	32.6	14 ± 1	0.890	5
B	as-grown	8.6	61.8	29.6	30	9.15	62	28.85	32	1.588	
	10' etched					9.15	62	28.85	28 ± 1	11.823	30
C	as-grown	5.4	62.6	32	9	5.4	62.6	32	8 ± 0.5	5.443	
	10' etched					5.4	62.6	32	5 ± 1	7.277	13 ± 3

Tab.: Values of composition, thickness, and rms roughness and etched depth obtained by means of RBS, XRD, and AFM.